Proceedings of the Institute of Acoustics

RECOGNITION AND DIFFERENTIATION OF NOISE EVENTS

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1. OVERVIEW

Using established Short Leq techniques, it is now possible to acquire short data elements or true integrals down to periods as short as 5 milliseconds. With the size of memories, up to 16 megabytes, now available in current generation sound level meters, these 5 millisecond raw data elements can be stored for continuous periods of nearly 24 hours. Using more conventional 1/16th second elements, 291 hours or 12 days of data can be stored, with 62,5 millisecond resolution. Even when Cirrus Research introduced the world's first conventional Short Leq meter in 1985, memory sizes such as this were almost unheard of and the storage of enough raw data was the prime concern.

Today, with problems of memory size being a relic of the past, attention focuses on processing the large amounts of raw data to give a much more detailed picture of the time history of the noise. The time history data and other related information can then be used to recognise individual noise events as they occur.

To give some idea of the techniques employed, the time history of a low flying Harrier aircraft is shown in figure 1. Using 10 millisecond Short Leq elements, the sudden rise of energy caused by the high speed jet suddenly appearing overhead, at about the speed of sound, is very obvious and is clearly likely to have a very high 'startle' effect. It is clear that very simple algorithms can be written to measure the rate of rise of the signal, the maximum level etc, to generate a 'startle' factor and indeed, such work is believed to be underway. In conventional 'outbox' processing, where all such processing is done on an external computer, the task is simple and indeed, the plot in figure 1 was made using the Cirrus software suite Acoustic Editor and the raw data recorded, or acquired, on a hand held sound level meter, as has been reported elsewhere (ref 1.).

With the rate of progress of computing technology, the task of computing these Short Leq values and storing them, is now trivial compared with the situation in 1984 when the first Short Leq meter was described (ref 2). Today's instruments are

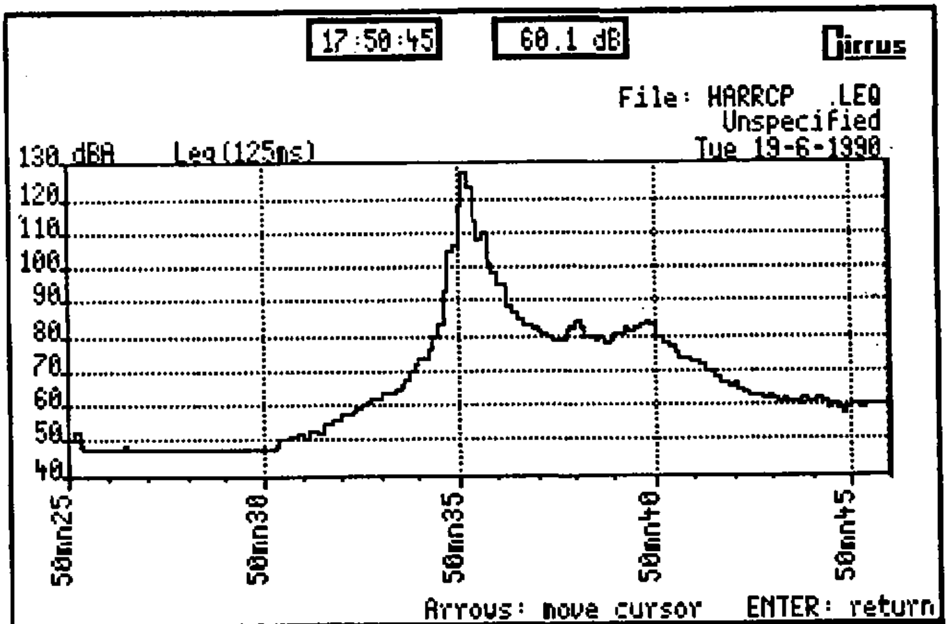

Figure 1 Time history of low flying aircraft

capable of storing raw data for subsequent re-processing, exactly like the earlier units but, in addition, have computing power to spare, to take on the task of shape recognition.

2. THE NEW GENERATION

The block diagram of the new generation of instruments is given in figure 2. Instead of the simple raw data memory of the earlier units, the current units have multiple memories, each one storing a different parameter, or indeed, series of parameters. Naturally, these multiple memories are only logically different and are simply partitions in a very large single physical memory. This means that the size of each memory partition can be varied by the user for different applications, allowing more raw data to be stored at the expense of 'recognized' events. A paper offered at Inter-noise 1990 (ref 3) shows a few possibilities of such a technique. However, in this paper, we wish to concentrate on aircraft event recognition. The new unit stores data using event recognition parameters and some background to the work puts the recognition task into perspective.

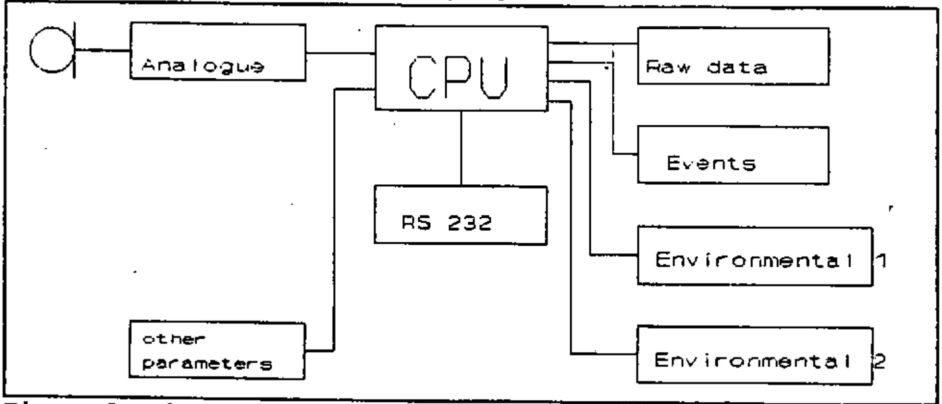

Figure 2 Block Diagram of the CRL243/1

In 1989 the decision was taken to upgrade the Noise Monitoring System at Sydney's Kingsford Smith International Airport and install a system at the International airport at Brisbane. To take advantage of new technology, the system was to inter-connect with the secondary surveillance radars at each airport, to generate flight track as well as individual aircraft noise data. In addition, the Civil Aviation Authority in Canberra, several hundred kilometres away, should be able to interrogate the system and obtain immediate data on the noise levels and track of any aircraft. To implement this system, a new version of the noise monitoring terminal, (NMT) was designed and automatic recognition was built in at each NMT to reduce the tasks required to be carried out by the central host computer. Figure 3 gives the block diagram of the system, which consists of several satellite noise monitoring terminals each connected 'on line' to a central host computer system. In fact, two host computers were used, one handling the communications with the terminals, the remote users and various external devices, while the other could concentrate on producing acoustic and database information, as required. Only three terminals are shown for clarity but there are currently 8 attached to the system, with the ability to add more if required. A wall map was to be incorporated which was to be updated once per second with the 1 second Short Leq at each terminal.

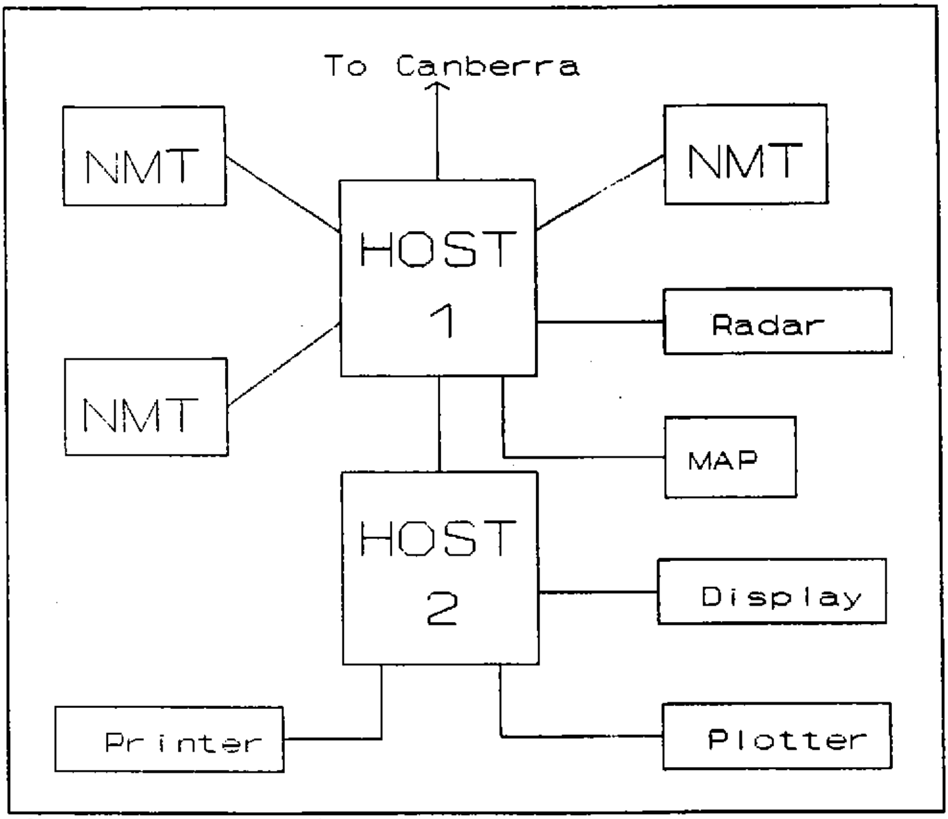

Figure 3 Layout of the Sydney System

3. THE NEW NOISE MONITORING TERMINALS

While the system contracted from Cirrus Adacel was very advanced in terms of radar interrogation and identification of aircraft identities and flight paths, the terminals themselves have the ability to recognize aircraft noise events from the general background noise of the city.

The basic system employed was a combination of thresholds below which all noise was disregarded for recognition purposes, minimum and maximum event times to take out very short events such as explosions, and guard times to test for events too long to be aircraft. Additionally, the terminal positioned at the end of the runway in Sydney had to have recognition of reverse thrust which could easily appear as a different event if the algorithms were too unsophisticated. In fact, reverse thrust at Sydney was one of the particular problems faced by the local community, as it seemed to have an annoyance well beyond that indicated by its Sound Exposure Level.

One of the remaining terminals was located near Bondi Beach where there were no large local noise sources, but the others were in busy urban streets with very high noise levels due to traffic. One, in particular, was placed on the roof of a town hall, located at a very busy intersection. The traffic lights at this intersection caused bunching, thus causing the noise level to vary very considerably from minute to minute, giving time histories not unlike aircraft.

These divergent noise patterns mean that, either each terminal has to be different to allow for the local noise climate, or the terminal has to be able to be re-configured 'on the fly' from the host or by a local portable computer. Such a configurable device can have its parameters set for event recognition under the current local conditions. Clearly, in terms of standardization, it is better to have a single design which can have its parameters changed remotely, rather than a series of terminals on a system each with its own special configuration. If each terminal has special parameters, it means that each one can only be used in one particular position, whereas if they are all the same, they can be moved around at will and the new parameters set into them from the host computer.

The Cirrus Research CRL 243/1 terminal is capable of such re-configuration and, in the Sydney application, the thresholds and other parameters can be varied from the host, as often as required, to meet the changing acoustic conditions. For example, the background noise level at 07:00 on Sunday morning is likely to be very different to that at 08:30 on Monday and thus the threshold is varied either manually or automatically to suit the different background levels, normally L90 being used as the determinant.

4. THE ALGORITHMS

Because the system at Sydney was to operate in a clearly defined manner, set by the Civil Aviation Authority, the algorithms used were chosen for simplicity rather than for the optimum 'hit rate'. Clearly any algorithm purporting to recognize noise events will not be 100% accurate. There will be false positives where an aircraft is identified when, in fact, there was none present and false negatives where a real aircraft will be missed. However, it was expected that with a relatively simple template comparison, such as the one shown in figure 4, there would be a 'hit rate' of over 95%, the typical sort of accuracy with such a simple system. One of the reasons for the choice of such a simple template was the fact that the system is directly connected to the airport secondary surveillance radar and this would send confirmation data that an aircraft was, indeed, present and give its identity. With these two sets of data, it was simple to increase the 'hit rate' to well over 99%. The system has only been in operation since January 1991 and, thus, better statistics are not yet available for the overall accuracy of recognition, but are expected to be presented elsewhere.

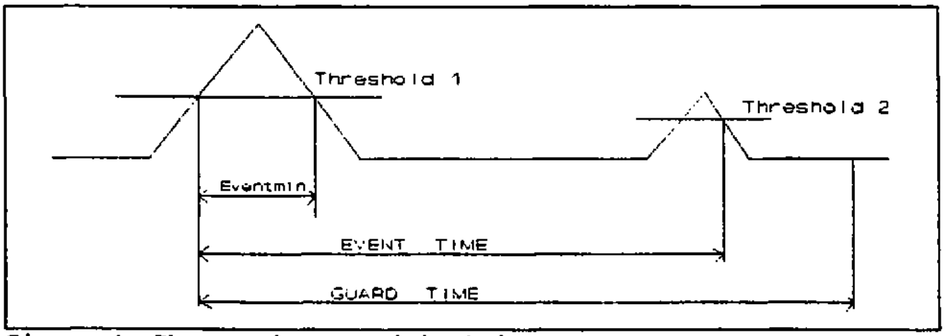

Figure 4 The template used in Sydney

The parameters of thresholds, minimum event time and guard time are all adjustable within very wide limits and, as the terminal is constantly calculating the running L90, the threshold above L90 can be changed internally if so desired, the first 'intelligence' in the unit. The data from the radar not only confirms the presence of an aircraft but gives its flight details etc. These are decoded from its IFF transponder return and this can reference the noise event to a specific flight, by name. It is obviously a trivial task for the host computer to put these details into a data base and provide noise levels, by type of aircraft or by airlines or whatever the operator decides is required. In fact, the Cirrus Adacel system has one of the most sophisticated data bases available, incorporated to give daily, weekly, monthly and annual reports, totally automatically.

5. MORE COMPLEX ALGORITHMS

Although not used at Sydney and Brisbane, the CRL 243/1 Terminal has provision for many more template parameters than the few used when the radar signal is available. For example, there can be 4 separate thresholds, two for the initial noise event and two more for any reverse thrust noise. Additionally, the guard time, minimum event, maximum event and the time between the two noise bursts can all be varied from the host. Thus if there was no connection to the radar, the terminal could achieve very high 'hit rates' without this added correlation.

Also available, in cases where there are no radar signal available, the CRL 243/1 can have a self contained transponder system where the terminal is equipped with two radio receivers. One 'hears' the initial signal from the airport radar, while the other 'hears' the transponder reply from the aircraft, see figure 5. The NMT then decodes the data and uses this to correlate the noise event information to improve the 'hit rate' and to give some evidence of the identity of the flight. Where there is no direct radar connection, this system gives some improvement to the recognition, but because there is often a multiplicity of planes flying round the airport, often one following the other, this system can give very misleading answers and falsely identify a flight. It is also open to abuse by operators who have been known to 'accidently' transpond with the wrong code, in fact, the code of a flight from the same carrier in a different physical position. The resulting incorrect identification can give rise to a lack of trust in the system. Today, the code is set by the pilot, but it is hoped that soon all aircraft will have permanent codes, built in at manufacture, to identify a particular plane rather than a flight. The original work on this concept appears to have been done in the USA, but it is now common in

Europe. The equipment needed to be added to the terminal is very simple and is effectively two modified aircraft IFF units with the re-transmitters removed and can be a very inexpensive option, about 25% of the terminal cost.

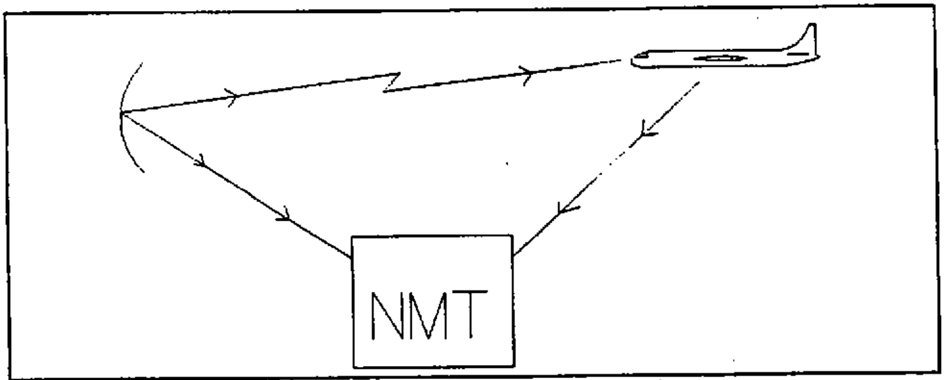

Figure 5 Self contained transponds correlation

6. MORE INTELLIGENCE

While the template parameters can be re-configured by the host, this begs the question of how this is done or rather what data is used to change these. Normally, of course, the operator of the system will have local data which will allow such changes to be made. There are, however, many airport sites where the operating staff have no knowledge of, nor interest in, the noise measuring system. In these cases, the Cirrus Adacel system can have 'learning' algorithms built in. It is really an exaggeration to call these self adjusting algorithms 'intelligence', but commercial imperatives use such a description and it is probably the nearest suitable description. In this technique, the terminal is set up with some reasonable template values. After a period of operation, the commissioning engineer inspects the data and enters the correct identification by hand. There will usually be both false positives and false negatives. The terminal then modifies its template and re-compares the new template with the existing raw data it has stored. By an iterative process, it tries more and more template adjustments until it has the best correlation possible with the events, as entered by the engineer. In this way, a very high 'hit rate' can be achieved and the unskilled operator does not have to worry about template changes at all.

7. SUMMARY

The huge memories and high processing power of current micro-controllers give the designers of noise monitoring terminals the ability to create units with very high computing power, while not in any way altering the original concept of 'outbox' processing. The use of an external desk-top computer then allows the software engineers to take the data from the terminal and assemble it into almost any order desired, in a very flexible manner. The use of either direct radar connection or simple IFF receiver techniques can significantly increase the recognition accuracy of such a system and give correct identification of events, with a very low error.

8. REFERENCES

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